REMARKS

The instant application was filed on February 22, 2002, and included Claims 1-19. In the Office Action, Claims 1, 3-15 and 17-19 stand rejected under 35 U.S.C. 102(b) as being anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over US Patent No. 6,108,295, issued to Ohno et al. on August 22, 2000, hereinafter "Ohno". , and Claims 1-19 stand rejected in the alternative under 35 U.S.C. 103(a) as being obvious over Ohno. Claims 1, 3-4, 8-15 and 17-19 stand rejected under 35 U.S.C. 102(e) as being anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over United States Patent Application Publication No. 2002/0160305, Horie et al., hereinafter "Horie". Claim 9 stands rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Examiner's rejections will now be discussed in detail.

Applicant's invention is directed at a multi-level recording material and device. Multi-level recording requires a material that possesses multiple recording levels that produce discrete and resolvable signals during read out. Each recording level produces a distinguishable signal on read out and each signal represents the unique information content associated with the recording level.

The top panel of Figure 2 of Applicant's specification presents an example where the read out signal of an embodiment of a multilevel recording medium is measured in terms of the scaled reflectivity of an incident read beam. Each plateau represents the signal level in reflectivity associated with a different recording level of the medium. The multiple levels available from Applicant's recording medium are evident in Figure 2.

Applicant's invention is concerned with increasing the amount of information that can be stored in an optical recording medium and presents multi-level recording as a strategy for accomplishing this objective. (p. 3, lines 25 – 29 of Applicant's specification: "One recognized limitation of present day, phase change data storage devices is in the capability to store increasing amounts of data. One system, which has been reported to increase the data storage capacity of conventional memory technology, is multi-level recording. Multi-level recording offers the potential to produce more than two bits of data per memory cell.")

In order to increase the amount of information capable of being stored in a given volume of a multi-level recording medium, it is necessary for the material to possess a high number of recording levels. The greater the number of recording levels is, the greater is the information density of the medium. As the number of recording levels is increased, however, the problem of resolvability of signals produced by the recording levels arises. A high number of recording levels implies a close spacing between levels and a commensurately smaller difference in the output signals associated with the levels.

Applicant's have identified a problem in the prior art associated with multi-level recording. (p. 4, lines 7 – 10 of Applicant's specification: "However, problems associated with accurately writing and detecting multiple signal levels have limited commercial use of multi-level recording applications. These problems occur primarily from poor signal to noise or sigma-to-dynamic range capabilities of the phase change recording material.") Poor signal to noise or sigma-to-dynamic range (SDR) properties of a material arise when there is a statistical variation in the output signal from the individual recording levels due to characteristics inherent in the recording process or recording material. In the

embodiment depicted in Figure 2 of Applicant's specification, for example, the output signal is the scaled reflectivity of each recording level and the statistical variation referred to corresponds to a spread or range of reflectivity associated each recording level. (p. 8, lines 5 – 8 of Applicant's specification: "For example, a desired signal level may have a target of 20% reflectivity. When writing to produce the desired signal level, the exact reflectivity may fall within a range of predictable values depending on the variability of the recording system and the recording device.")

The statistical variation in output signal means that a range of output signals becomes associated with a given recording level and this range of output signals corresponds to the standard deviation of the recording level used in Applicant's SDR figure of merit. The SDR is the ratio of the standard deviation of the output signal from a recording level to the full range of signal available from the recording medium. When the output signal is measured in terms of reflectivity, for example, the SDR corresponds to the ratio of the standard deviation of the reflectivity of a recording level to the full range of reflectivity available from the recording medium.

In a multi-level recording medium, the SDR governs the number of available resolvable recording levels. A medium with a high SDR requires a large spacing between recording levels in order to maintain resolvability. This follows because a high SDR arises when the standard deviation of output signal from a recording level is large. If the spacing between adjacent recording levels is small, a large standard deviation leads to a significant overlap of output signals produced by adjacent recording levels. As a result, when one measures an output signal and attempts to identify it with a particular recording level, one is unable to determine which recording level of the medium produced the

signal because many different recording levels are capable of producing a particular output signal level when the standard deviation is large and the levels are closely spaced. The recording levels are unresolvable under these conditions. Significant overlap between the range of output signals from different recording levels defeats the one-to-one correspondence between output signal and recording level needed to accurately determine the information content of the recording medium.

In order to maintain the resolvability of output signal, the spacing of recording levels must be sufficient to prevent or at least minimize overlap of output signal from adjacent levels. Overlap of output signal can be adequately avoided by spacing the recording levels by an amount corresponding to the standard deviation. (p. 7, lines 24 – 25 of Applicant's specification: "Signal levels are preferably spaced by an amount equal to the standard deviation of writing a signal level.")

Applicant's objective of obtaining a high number of recording levels that produce resolvable output signals is achieved in the instant application through the invention of multi-level recording media having a low SDR. (p. 8, lines 17 – 18 of Applicant's specification: "Well defined levels, as seen in this figure, are an indication of a low SDR.") In the embodiment of Applicant's recording medium presented in Figure 2, the output signal is the scaled reflectivity and the value of the output signal is controlled by the relative proportion of crystalline and amorphous phases of the recording medium. (p. 7, lines 27 – 29 of Applicant's specification: "Signal level is a function of reflectivity and is measured by a response in voltage. Reflectivity is a function of crystallization over a given area or volume of memory material.") The reflectivity increases as the fractional crystallinity of a volume of recording material increases. In the top panel of Applicant's

Figure 2, for example, the high reflectivity output signals observed toward the right of the panel are produced by recording levels having a high fractional crystallinity and the low reflectivity output signals observed toward the left of the panel are produced by recording levels having a low fractional crystallinity.

The SDR of Applicant's recording medium is thus governed by statistical variations that occur in the process of crystallizing (or recrystallizing) the recording medium. A low SDR (and a high number of resolvable recording levels) requires that a low standard deviation in the fractional crystallinity of the recording medium be achieved.

Applicant maintains that the SDR of the material of amended claim 1 is unexpectedly low. Applicant further maintains that for the compositional ranges recited in amended claim 1, the statistical variation in the crystallinity of the recording levels of the recording medium is unexpectedly low.

In support of Applicant's contentions, Applicant has completed experiments that show the variation of SDR with In concentration in the $In_x(Sb_nTe_{100-n})_{100-x}$ system. The experimental results are included in the publication entitled "InSbTe Phase-Change Materials for High Performance Multi-Level Recording" which was filed with Applicant's response of August 22, 2003, and which was referred to therein as "Document B". Similar results are included in Table 2 of Applicant's specification as well. The Examiner is referred to Fig. 2 on p. 796 of Document B. This figure shows the SDR of $In_x(Sb_{72}Te_{28})_{100-x}$ as a function of the In concentration x at three different speeds. The SDR data show an oscillatory, double minimum type behavior in their variation with In concentration.

Applicant maintains that the oscillatory dependence of SDR on In concentration is unexpected and specifically that the decrease in SDR that is observed in the two minima of the data plot is unexpected and provides an unexpectedly beneficial result in connection with Applicant's objective of achieving a multi-level recording medium that provides for a high number of resolvable recording levels. Applicant specifically notes the criticality of the In concentration ranges (7.4 – 18 and 25 – 30) associated with the minima in the data plots and notes that these ranges are specifically recited in claim 1 as amended. Applicant further notes that the SDR values outside of Applicant's critical ranges are 50% or more greater than the SDR values within Applicant's critical ranges.

1. Claims 1, 3-15 and 17-19 stand rejected under 35 U.S.C. 102(b) as being anticipated or, in the alternative under 35 U.S.C. 103(a) as being obvious over Ohno.

Regarding claims 1 and 3-8 Examiner contends that Ohno discloses an optical information recording medium that incorporates a phase change alloy used in an optical disk and that the recording/erasing is carried out by a three power level modulation. Further, the phase change alloy is used in the recording layer made of a thin film of $M_y(Sb_xTe_{1-x})_{1-y}$, wherein $0 \leq y \leq 0.3$, $0.5 \leq x \leq 0.9$ and M_y may be selected from a group which includes In. Applicants have amended Claims 1 and 9 to claim ranges wherein x is 7.4-18 or 25-30. These ranges show unexpected results in the alloy that enable multi-level recording. Applicants' invention is directed to a multi-level recording medium. Ohno does not disclose or suggest the multi-level recording device of the Applicant's invention. As discussed in "InSbTe Phase-Change Materials for High Performance Multi-Level Recording", which was filed with the Applicants August 22, 2003 response as

"Document B", on page 795 column 1, a copy of which was previously provided to Examiner, the accuracy of achieving each of the specified levels in a multi-level media determines the maximum number of levels that can be used to write data. If the standard of deviation of the written reflectivity levels is large, the levels need to be spaced further apart for accurate identification of the levels. If the reflectivity range can be increased, additional levels can be used. This relationship is expressed as a ratio of the standard deviation of the written reflectivity distribution for each intended level normalized to the entire reflectivity range, or in other words, the sigma-to-dynamic range (SDR). On page 796 of the above referenced publication, figures 2(a)-2(c) illustrate the benefit of the claimed ranges. The unexpected benefit of these claimed ranges are disclosed in the Application in Table 2 on pages 9 and 10. The SDRs at in the claimed ranges for x comprising 7.4-18 and 25-30 in the alloy $In_x(Sb_nTe_{100-n})_{100-x}$ are acceptable at varying linear track velocities, e.g. 1.9 m/s, 3.5 m/s and 6.0 m/s, whereas Ohno does not disclose or contemplate phase change alloys having the necessary qualities to produce a multi-level recording medium of the present invention.

Applicant agrees that Ohno discloses a range of alloys for use in an optical recording medium that encompasses the alloys used in the multi-level recording device of the present invention. However, MPEP 2131.03 reads "When the prior art discloses a range which touches, overlaps or is within the claimed range, but no specific examples falling within the claimed range are disclosed, a case by case determination must be made as to anticipation. In order to anticipate the claims, the claimed subject matter must be disclosed in the reference with "sufficient specificity to constitute an anticipation under the statute." What constitutes a "sufficient specificity" is fact dependent. If the claims are

directed to a narrow range, the reference teaches a broad range, and there is evidence of unexpected results within the claimed narrow range, depending on the other facts of the case, it may be reasonable to conclude that the narrow range is not disclosed with "sufficient specificity" to constitute an anticipation of the claims. The unexpected results may also render the claims unobvious." The language relied upon by Examiner can be found at column 4, lines 38-61 of the Ohno. The phase change alloy of the recording medium of the Ohno is $M_y(Sb_xTe_{1-x})_{1-y}$, wherein $0\leq y \leq 0.3$, $0.5\leq x \leq 0.9$ and M_y is at least one member from selected from the group consisting of In, Ga, Zn, Ge, Sn, Si, Cu, Au, Ag, Pd, Pt, V, Nb, Ta, Pb, Cr, Co, O, S and Se. Applicants contend that the broad range of alloys of the Ohno does not disclose the Applicants' invention with "sufficient specificity" to constitute anticipation. Further, the Ohno discloses no examples wherein M_y is In only. The phase change alloy included in the multi-level recording medium of currently amended claim1 is $In_x(Sb_nTe_{100-n})_{100-x}$ wherein x is 7.4-18 or 25-30 and n is 63-82. The use of In in amounts claimed by the present invention, i.e. 7.4-18 or 25-30, give unexpected results in view of the 295' Patent. The Applicants submit that Table 1 of the Application shows the unexpected superior performance of InSbTe disks when compared to AgInSbTe disks. Systems containing AgSbTe tend properly crystallize with the two pulse melt crystallization only at slow linear track velocity, e.g. 1.9 m/s, whereas the InSbTe disks maintain acceptable performance, i.e. SDR below 1.5%, at 1.9 m/s, 3.5 m/s and 6.0 m/s. Referring to Document B, Fig. 1 illustrates the superior performance of In at various linear track velocities in producing a multi-level recording device. At linear track velocities of 1.9 m/s, 3.5 m/s and 6 m/s, respectively, the InSbTe disks produced a sigma-to-dynamic ratio (SDR) acceptable for producing a multi-level recording device, whereas the

AgInSbTe disks produced unacceptable SDRs at 3.5 m/s and 6.0 m/s, which are 1.51% and 2.12%, respectively, as illustrated in Table 1. On page 796 of Document B, figures 2(a)-2(c) illustrate the benefit of the claimed ranges. The peaks between In concentration of 18% and 25% show SDRs that are not conducive to producing a multi-level recording device. The Ohno reference does not disclose or render obvious the critical ranges of the present invention, i.e. 7.4-18 and 25-30, that enable a multi-level recording device that has an adequate number of sufficient and distinct reflectivity levels.

Claims 3, 4 and new claim 20, which depend from claim 1, narrow the value of x (i.e. In concentration) and Claims 5-7, which also depend from claim 1, claim multi-level recording devices having specific alloy compositions that have beneficial characteristics for producing a multi-level recording device. As evidenced by Appendix A (figures 2(a)-2(c) on page 796 of Document B) and Table 2 of the application, In concentrations of 9-13, 9-15 or 30 exhibit particularly low SDRs at varying linear track velocities, in contrast to the general alloy formulas disclosed in Ohno. The inventor has found that the multi-level recording device of Claims 5-7 incorporate very specific alloys that possess specific unexpected beneficial characteristics, characteristics not described or disclosed in Ohno.

Applicant maintains that Ohno's broad disclosure of In concentration over the 0 – 30% range does not disclose Applicant's claimed critical ranges of In concentration with sufficient specificity to anticipate or render obvious Applicant's claimed critical range. Applicant maintains that Ohno does not provide adequate guidance or direction to one of ordinary skill in the art to operate within Applicant's claimed critical range. Ohno provides no guidance or teaching as to the relationship between In concentration and the standard deviation of the fractional crystallinity of a recording medium. Ohno further provides no

guidance or teaching as to the relationship between In concentration and the standard deviation of output signals produced by the recording levels of a recording medium. Applicant further notes that a variation in In concentration is not an art-recognized results effective variable for achieving a recording medium having a low SDR. Applicant maintains, therefore, that Ohno does not anticipate or render obvious Applicant's claim 1 as amended. Claims 3-8 and 20 depend from claim 1. If Examiner finds amended claim 1 to be allowable, Applicant contends that claims 3-8 and 20 will be allowable.

With respect to claims 3-7 and 17-18, Examiner contends that Ohno does not specifically exemplify the specific formula of the phase change alloy as claimed by Applicant. Although Ohno does not disclose specific examples the presently claimed formula of the phase change alloy, the range for the ratio of Sb/Te is entirely encompassed by the ranges of Ohno, a point with which the Applicant agrees. Absent a showing of unexpected results with the claimed limited range, no patentable distinction is seen. As discussed in detail above, the claim limited range, wherein x is 7.4-18 or 25-30, shows unexpected results and patentable distinction over Ohno.

With respect to claims 9-15 and 19 Examiner contends that Ohno discloses an optical information recording medium that incorporates a phase change alloy used in an optical disk and that the recording/erasing is carried out by a three power level modulation. The phase change alloy is used in the recording layer made of a thin film of $M_y(Sb_xTe_{1-x})_{1-y}$, wherein $0 \leq y \leq 0.3$, $0.5 \leq x \leq 0.9$ and M_y may be selected from a group which includes In. Further, Examiner contends that because Ohno exemplifies the Applicant's claimed phase change formula, the claimed physical properties relating to X-ray diffraction and sigma-to-dynamic ratio as well as the detectable levels are inherently

present in the prior art. Applicant agrees that a chemical composition and its properties are inseparable; however, claims 9-15 and 19 are directed to a multi-level recording device that is enabled by the unexpected characteristics, as discussed above, of the alloy used in the device. Ohno provides no specific examples that may provide the unexpected characteristic claimed in claim 9.

2. Claims 1, 3-4, 8-15 and 17-19 stand rejected under 35 U.S.C. 102(e) as being anticipated or, in the alternative under 35 U.S.C. 103(a) as being obvious over Ohno.

Regarding claims 1 3-4 and 8, Examiner contends that Horie discloses an optical recording medium having a recording layer comprised of a Sb-Te eutectic composition having the formula Sb_xTe_{1-x}, wherein $0.75 \leq x \leq 0.9$. Further, a dopant such as In can be added to the eutectic composition in order for fine adjustment of the optical constants of the recording layer or suppression of nucleation and the eutectic composition, including the dopant (M_y), has the formula $M_y(Sb_xTe_{1-x})_{1-y}$, wherein $y \leq 0.2$, and x is $0.75 \leq x \leq 0.9$. The recording layer can be applied to recording mediums having multi-level recording, meeting the requirements of claims 1 and 3-4. Applicants will agree that Horie generally discloses an alloy for use in an multi-level optical recording medium that, on its face, encompasses the range of the alloy of the Applicants multi-level recording device. However, Horie does not disclose with "sufficient specificity" the alloy of the Applicant's device, namely $In_x(Sb_nTe_{100-n})_{100-x}$ wherein x is 7.4-18 or 25-30. As discussed above with regard to the Ohno reference, the range of x, 7.4-18 or 25-30, shows unexpected results in the alloy that enable the multi-level recording recording device of the present invention. Horie does not disclose or suggest the multi-level

recording device of the Applicant's invention. As discussed in "InSbTe Phase-Change Materials for High Performance Multi-Level Recording", which was filed with the Applicants August 22, 2003 response as "Document B", on page 795 column 1, a copy of which was previously provided to Examiner, the accuracy of achieving each of the specified levels in a multi-level media determines the maximum number of levels that can be used to write data. If the standard of deviation of the written reflectivity levels is large, the levels need to be spaced further apart for accurate identification of the levels. If the reflectivity range can be increased, additional levels can be used. This relationship is expressed as a ratio of the standard deviation of the written reflectivity distribution for each intended level normalized to the entire reflectivity range, or in other words, the sigma-to-dynamic range (SDR). On page 796 of the above referenced publication, figures 2(a)-2(c) illustrate the benefit of the claimed ranges. The unexpected benefit of these claimed ranges are disclosed in the Application in Table 2 on pages 9 and 10. The SDRs at in the claimed ranges for x comprising 7.4-18 and 25-30 in the alloy $In_x(Sb_nTe_{100-n})_{100-x}$ are acceptable at varying linear track velocities, e.g. 1.9 m/s, 3.5 m/s and 6.0 m/s, whereas Horie does not disclose or contemplate phase change alloys having the necessary qualities to produce the multi-level recording medium of the present invention. Further, Horie does not differentiate the applicable alloys between conventional two levels of writing and multi-level (page 17, section 0203). Whereas, the present Application claims a multi-level recording device, wherein very specific alloys (i.e. $In_x(Sb_nTe_{100-n})_{100-x}$, $7.4 \leq x \leq 18$ or $25 \leq x \leq 30$, $63 \leq n \leq 82$) enable a device that has reflectivity levels spaced at an optimal distance to produce a multi-level device.

Applicants contend that the test data shows the unexpected results of using In concentration of 7.4-18 or 25-30.

Claim 1 has been amended to narrow the range for In concentration in the phase change alloy of the multi-level recording device of claim 1. The range for x has been amended to include 7.4-18 or 25-30. This range encompasses the unexpected results as discussed above. Claims 3-4, 8 and 20 depend from claim 1. If Examiner finds amended claim 1 to be allowable, Applicant contends that claims 3-8 and 20 will be allowable.

With respect to claims 3-4 and 17-18, Examiner contends that Horie does not specifically exemplify the specific formula of the phase change alloy as claimed by Applicant. Although Horie does not disclose specific examples the presently claimed formula of the phase change alloy, the range for the ratio of Sb/Te is entirely encompassed by the ranges of Horie, a point with which the Applicant agrees. Absent a showing of unexpected results with the claimed limited range, no patentable distinction is seen. As discussed in detail above, the claim limited range, wherein x is 7.4-18 or 25-30, shows unexpected results and patentable distinction over Horie.

With respect to claims 9-15 and 19 Examiner contends that Horie discloses an optical recording medium having a recording layer comprised of a Sb-Te eutectic composition having the formula Sb_xTe_{1-x}, wherein $0.75 \leq x \leq 0.9$. Further, a dopant such as In can be added to the eutectic composition in order for fine adjustment of the optical constants of the recording layer or suppression of nucleation and the eutectic composition, including the dopant (M_y), has the formula $M_y(Sb_xTe_{1-x})_{1-y}$, wherein $y \leq 0.2$, and x is $0.75 \leq x \leq 0.9$. Further, Examiner contends that because Horie exemplifies the Applicant's claimed phase change formula, the claimed physical properties relating to X-

ray diffraction and sigma-to-dynamic ratio as well as the detectable levels are inherently present in the prior art. Applicant agrees that a chemical composition and its properties are inseparable; however, claims 9-15 and 19 are directed to a multi-level recording device that is enabled by the unexpected characteristics, as discussed above, of the alloy used in the device. Horie does not disclose a multi-level recording device comprising a substrate, a memory material supported by the substrate, the memory material including the phase change alloy $In_x(Sb_nTe_{100-n})_{100-x}$, $7.4 \leq x \leq 18$ or $25 \leq x \leq 30$, $63 \leq n \leq 82$, because Horie does disclose the present invention with "sufficient specificity" to be considered an anticipation. Also, in view of the unexpected results, claims 9-15 and 19 are unobvious over Horie.

3. Claim 9 stands rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Examiner cites *Ex parte Slob*, 157 USPQ 172, hereinafter "Slob", as authority that Claims setting forth physical characteristic in an article, and not setting forth specific compositions, which would meet such characteristics, are invalid as vague, indefinite, and functional since they cover any conceivable combination of ingredients either presently existing or which might be discovered in the future and which would impart the desired characteristics. However, exceptions may be applied to that general rule. Under *In re Swinehart*, 439 F.2d 210, 169 USPQ 226 (CCPA 1971), A functional limitation is an attempt to define something by what it does, rather than by what it is (e.g., as evidenced by its specific structure or specific ingredients). There is nothing inherently wrong with defining some part of an

invention in functional terms. Functional language does not, in and of itself, render a claim improper. Although Claim 9 is directed at a functional part of the multi-level recording device claimed, Applicant contends that claim 9 sets definite boundaries on the patent protection sought. Under *In re Barr*, 444 F.2d 588, 170 USPQ 33 (CCPA 1971), it was held that the limitation used to define a radical on a chemical compound as "incapable of forming a dye with said oxidizing developing agent" although functional, was perfectly acceptable because it set definite boundaries on the patent protection sought. Claim 9 is directed at a multi-level recording device comprising a substrate and a phase change alloy supported on the substrate, the phase change alloy lacking silver and having a eutetic base alloy composition with at least one element for providing a sigma-to-dynamic range of less than 2%. The objectionable part of the claim in Slob claims "a liquefiable substance having a liquefaction temperature from about 40° C to about 300° C and being compatible with the ingredients in the powdered detergent composition". The opinion goes on to state "this language purports to cover everything which will perform the desired functions regardless of its composition, and, in effect, recites the compounds by what it is desired they do rather than what they are." Claim 9 specifically identifies a "phase change alloy lacking silver and having an eutetic base alloy composition with at least one element for providing a sigma-to-dynamic range of less than 2%". This is very different from the broad generic term "liquefiable substance". Further, the phase change alloy of claim 9 focuses to one that "lacks silver" and "an eutectic base alloy with at least one element" to provide the desired function. A specific example of "at least one element", In, is provided. In conclusion, claim 9 adequately describes the patent protection sought and provides legally sufficient boundaries to be considered patentable.

4. In view of the discussion as set forth above and the papers provided, Applicants contend that all rejections have been overcome and Claims 1, 3-15 and 17-20 are in condition for allowance. Claims 1 and 15 have been amended and Claim 20 has been added. Applicants respectfully request reconsideration of the present application. Applicants respectfully request that Examiner withdraw the rejections and objections and that a timely notice of allowance be issued with Claims 1, 3-15 and 17-20. Should the Examiner have any comments or suggestions that would place the instant application in better condition for allowance, please contact the undersigned.

Respectfully Submitted,

Anthony J. Serventi
Attorney No. 42141

Date:

Energy Conversion Devices, Inc.
2956 Waterview Drive
Rochester Hills, MI 48309
Tel: (248) 293-0440 x6253
Fax: (248) 844-2273
e-mail: ajserventi@msn.com